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Three experiments were conducted to investigate the learning of the concept "more than" by preschool children. In the first experiment, 48 nursery school children, ages 4 1/2 to 5 1/2 years, were divided into three groups. All were required to say which of two pictures contained the greater number of objects. In group one, circles were used as the objects in the picture; for group two, like objects were used in each pair, but the types of objects varied between pairs, and in group three, unlike objects were used in the pictures. For each group, 42 trials were conducted per day for 3 days or to a criterion of eight consecutive correct responses. Subjects in groups one and two who reached criterion were given the same procedure again, except with unlike objects (a transfer condition). The results showed that subjects who initially learned the concept with the simplest stimuli (group one) learned most efficiently. Experiment two substantially replicated the results of experiment one, using children 41 to 51 months of age. Experiment three did likewise, using children with a mean age of 38 months. The overall results indicated that concept learning in young children was most efficient when the concept was introduced in the simplest context. (WD)

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Final Report

INVESTIGATION OF CONCEPT LEARNING IN YOUNG CHILDREN

Three problems to be investigated were described in the original project proposal. These were:

a. The experimental investigation of the learning of inequalities by young children (four and five-year-olds).

b. The facilitation of recall of learned concepts in young children.

c. The effect of using the "correction method" in a situation in which stimulus and response are spatially separated.

Investigation of (a) above, generated so many related and imported problems (the area is a new one for experimental investigation) that most of the research during the grant period has been concerned with some aspect of the learning of the concept of inequalities by young children.

The experimental situation has proved both interesting and fruitful. The experiments performed have been largely concerned with the establishment of experimental conditions a)in which young children could learn the experimental concept b)which would facilitate rapid learning of the concept and c)to ensure transfer of the same concept to more difficult situations. Finally we were also concerned with extending the experimental learning situation to include much younger children.

Of the experiments performed, Experiment 1 will be described in some detail as this provides a model which the remaining experimental work follows.

<u>Pilot work</u> Pilot work with some twelve $4\frac{1}{2}$ to $5\frac{1}{2}$ year olds indicated that the concept of "more than" was more quickly learned, and a higher

level of learning achieved (within 60 trials) than "less than". Consequently the concept of "more than" was used as the experimental concept to be learned throughout.

Experiment 1

Subjects: The Ss, 48 nursery school children ranging from 4½ to 5½ years old, were randomly assigned to three groups.

Experimental task: The Ss were run individually. On each trial a child was presented with two pictures - each picture behind a clear plexiglass window. The child was required to choose one of the pictures and indicate his choice by pressing that window. Following pressure on the correct plexiglass window the picture lit up. Following an incorrect response (the light did not go on) the child was required to make an overt correction response. On every trial the "correct" picture was the one of the pair containing the greater number of objects.

Apparatus: Essentially the apparatus[1] was a box with two plexiglass windows on the side facing S. On each trial E inserted in a slot at the side of the apparatus a pressboard frame containing two pictures each stamped on a 4" square of translucent plastic. A hinged board on each side of the front of the apparatus prevented S from seeing the stimuli until the pictures appeared in the two windows. As each pressboard frame was programmed so that pressure on the correct picture only would be reinforced, E was required, on each trial, only to insert and remove the pressboard

1. A detailed description of the apparatus is available if required.

containing the stimulus pictures and to record S's response.

Stimuli: The stimuli consisted of pressboard frames, each of which contained two pictures which were presented on a single trial. Each picture in any pair of stimulus pictures consisted of from 2 to 6 objects with a difference of no more than 2 objects between two pictures of a pair. Each number of objects (from 2 to 6 inclusive) was paired 6 times with each number within that range which differed from it by no more than 2.

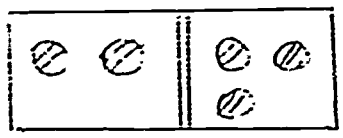
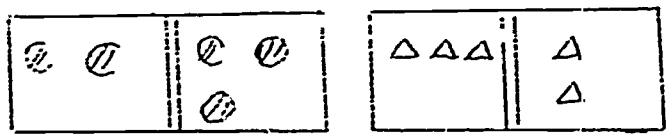
Six different geometrical arrangements of each number of objects were used and no pair of arrangements was used more than once. In all three groups the "correct" picture, that is the one with the greater number of objects, appeared equally often on the left and right and no 2 pairs of stimulus pictures were exactly alike for any child during a single session.

The three sets of stimuli used for the three groups of children, varied only in respect to the kind of objects which made up each pair of pictures. The number of objects in the pairs of pictures, the geometric arrangements of the objects were matched across groups.

The simplest set of stimuli - used for Group 1 - to be called here "circles", were made up entirely of striated circles. The set for Group 2 ("like objects") were made up of objects which were all alike on a single trial, but differed from trial to trial. In the Group 3 set of stimuli ("unlike objects") every object in a pair of pictures on any single trial was different. Table 1 presents examples from each set of stimuli. Fourty-two pairs of pictures were made up for each of the three sets.

Table 1

Experimental Stimuli

		Examples	Description
oup 1	Circles	 *	All stimuli made up of striated circles
oup 2	Like Objects	 * *	The same objects within a trial, different objects across trials
oup 3	Unlike Objects	*	Different objects both within and across trials

* Each picture of a pair of pictures is made up of from 2 to 6 objects.

A highly restricted randomization procedure was used to prepare the sequence of pictures presented to each child, such that alternations and long runs of reinforcement on the same side were minimized. A different randomization was used for each child in Group 1 and the randomizations were matched across groups.

Procedure: Each S was taken through 42 trials per day for a maximum of 3 days on a particular set of stimuli, or to criterion of 8 consecutive correct responses. The set used for Group 1 was "circles", for Group 2 "like objects" and for Group 3 "unlike objects". Subjects reaching

criterion in Groups 1 and 2 were subsequently taken through a further 42 trials a day to criterion, or a maximum of 3 days on "unlike objects". Table 2 presents the experimental design.

Table 2

Experimental Design

Group	N	Pretraining Stimuli	Transfer Stimuli	Experimental Task
I	12	Circles	Unlike Objects[1]	For all Ss the experimental task is "more than"
II	24	Like Objects		
III	12		Unlike Objects	

1) Learners only, in Groups I and II, are taken through the transfer task.

Results

The results in respect to the number of learners in each Group, mean trials and mean errors to criterion are summarized in Table 3.

Table 3

Summary of Results

	Group 1	Group 2	Group 3
Number of learners			
Pretraining	8/12	11/24	4/12
Transfer	8/8	11/11	
Mean trials to Criterion	1)Pretraining Task	Pretraining Task	
	45	60	64
	2)Transfer Task	Transfer Task	
	17	30	
Mean errors to Criterion	1)Pretraining Task	Pretraining Task	
	14	20	25
	2)Transfer Task	Transfer Task	
	3	8	

From Table 3 it can be seen that:

1. The proportion of Ss reaching criterion on the initial task was inversely related to the difficulty of the stimuli, in about 30% of the Ss given initial training on "unlike objects" reached criterion, less than half learned "like objects" and about 60% learned on "circles".
2. All learners initially given training on "circles" and "like objects" transferred to unlike objects.
3. Learners on "like objects" took as many trials to criterion and made as many errors on that task as those given "unlike objects" initially.
4. Subjects initially trained on "circles" reached criterion on that task and transferred to "unlike objects" in much the same total number of trials (62 as compared to Group 3's 64 mean trials to criterion) but with fewer errors (17 as compared to 25) than those given training only on "unlike objects". And, of course, twice the Ss in Group 1 reached criterion (and went on to reach criterion on "unlike objects") than reached criterion in Group 3.

Discussion

The results of the present study indicate that young children can learn tasks which would otherwise be too difficult for most of them, if they are given pretraining on a simpler, but related, task. In fact the findings show that, at least within the range of variables used here, the simpler the stimuli used in the preliminary training, the faster Ss will learn the initial task and moreover, once the concept is learned under the simple

conditions S transfers easily to the situation where the same concept is relevant, but the stimuli themselves are highly complex.

I originally suspected that under the conditions of the present experiment, young children would successfully learn the experimental concept but I expected that Group 2 (the same objects within a pair of pictures, but different objects across pairs - i.e., "like objects") would provide the most efficient conditions for subsequent transfer. In fact, clearly the "circles" condition was by far the most effective. It appears that the effect of increasing the difficulty of the stimuli in initial learning may at the same time increase the difficulty of attending to the relevant dimension. The possibility - that Ss may be confused by the irrelevant features of the stimuli and thus not learn to attend only to number finds some support in the following evidence: Those Ss who failed to reach criterion in Group 2 ("like objects") were given additional training on circles, until they reached criterion. Subsequently the learners were transferred to Group 3 conditions ("unlike objects"). A large proportion of the Ss did learn under "circles" conditions - but very few subsequently transferred successfully. Apparently, once the child is confused during initial training by irrelevant features - such as are present in "like objects" stimuli - the effect is pervasive and lasting.

A final conclusion - if the conjectures described are correct - and certainly given the experimental results reported here, is that the child should learn new concepts under the simplest conditions - so that his attention to the relevant dimension is assured. There seems, from the present study, no advantage to be gained by adding complexity to a learning

situation where a new concept is to be introduced.

One further interesting observation - in the present Experiment more children learned the experimental concept than anticipated, basing expectations on previous experience in preliminary studies. It seems both from the results of Experiment 1 and the two subsequent Experiments to be described, that the effectiveness of the experimental learning situation must, at least in part, be a function of the simple but excellent piece of apparatus used which ensured spatial and temporal contiguity of stimulus, response and reinforcement - factors which have been experimentally shown to facilitate learning in young children.

Experiment 2

Subjects: The Ss were 44 nursery school children ranging in age from 41-51 months, with a mean age of 46 months. The Ss were randomly assigned to 4 groups.

Experimental task and apparatus: The task was the same as the one described in Experiment 1. The apparatus was the same as for Experiment 1, and the task was again, inequalities, with S required to learn to choose the picture in each pair of pictures with the most objects in it, and to indicate his choice by pressing the chosen picture. Again overt correction procedure was used.

Stimuli: In the stimuli used for these younger children each picture consisted of from 1 to 3 objects - instead of the 2 to 6 objects used for the older children. Different geometric arrangements of each number of objects were used and no pair of arrangements was used more than once. The sequence of pictures presented to each child was randomized but the restric-

tions were considerable - for example the "correct" picture was not presented more than twice successively on the same side and the number of successive alternations was restricted to 4. A different randomization was used in Group 1 and was matched across the other three groups.

Procedure: The procedure was the same as for Ss in Experiment 1 except that the maximum number of trials on each day for each child was 36 (instead of 42). Otherwise S was taken through 36 trials per day for a maximum of 3 days or to a criterion of 8 consecutive correct responses, on "circles". Subsequently learners in Groups 1 and 3 were transferred to "unlike objects".

In fact Groups 1 and 2 exactly duplicated Groups 1 and 3 of Experiment 1 (with the exception of the number of trials per day and the number of objects in each stimulus picture). In Groups 3 and 4 the instructions given to Groups 1 and 2 Ss were amplified by inclusion of the statement "press the picture with more balls" - in all other respects Group 1 conditions were identical with those of Group 1, and Group 4 were identical with Group 2.

In Experiment 2 therefore, the learning of "more than" was examined with still younger children - but on the evidence presented by the results of Experiment 1 only the most efficient learning conditions were used - i.e., "circles" for initial training and subsequently transfer from "circles" to "unlike objects" was examined. Comparison groups learning only "unlike objects" were of course, also included. The new independent variable in this case, was the instructions which, in two of the Groups, permitted S to use any verbal comprehension of the concept that he may have acquired.

Results

Of the 10 Ss in Group 1, nine learned the initial task ("circles") and

all the learners transferred successfully to the more difficult task ("unlike objects"). In Group 2 only 6 of the 10 children reached criterion on the more difficult set of stimuli.

Of the 14 children in Group 3, all learned the initial task and 13 of the 14 transferred successfully to the more difficult task. Of the 10 children in Group 2, three did not learn.

Discussion

It is clear from the results presented here that the concept of "more than" is easily learned by children as young as 3½ years when the stimuli are of the kind described here and the number of objects in each set presented in pairs to the child, are no more than 3. Also when the child's attention has been directed to the number dimension, in the simple situation, he seems to have very little difficulty in transferring to the more complex stimuli. The evidence suggested by the results of Experiment 1 seems even more clearly supported in the present Experiment, that is that a young child can learn concepts commonly considered to be beyond his capacity, if the situation in which the concept presented is sufficiently simple. And -- most surprisingly and quite unexpectedly - he seems then able to transfer quite easily to difficult situations.

Whether the child of this age can deal as successfully with stimuli involving more than three objects per picture in a pair of pictures, remains to be investigated.

Experiment 3

In Experiment 3, the Group 1 situation of Experiment 2 was exactly repeated with still younger children (mean age 38 months). The same stimuli

and apparatus were used - the children being first taken through 36 trials a day on three successive days or to criterion of 8 successive correct responses on "circles". The learners in the "circle" situation were then taken through the same succession of trials or to criterion on "unlike objects". There was no independent variable in this experiment - the question being asked was simply "can the three-year-old learn the experimental concept - and if he learns can he transfer to the more complex situation?" Only 8 Ss were taken through the experimental conditions. The major difference between the situation in Experiment 3 and that of the previous Experiment was that with the youngest children, E sat next to the child throughout the experiment and repeated at the beginning of each trial - and of every trial where necessary - "look at this picture --- ~~now look at this picture~~ (E points to one of the pictures) now look at this picture" (E points to the other picture). "Now press a picture."

Results

All of the eight children learned under "circles" conditions and of the 8 learners, all transferred successfully under "unlike objects" conditions. The mean trials to criterion on the initial "circles" task was 17.5 and on the transfer "unlike objects" task, 14.6.

Discussion

The results with the 8 very young children are quite striking. The children were all pupils in a Day Care Home which caters largely to children from broken homes, and where the costs of attendance are adjusted in accordance with the financial status of the family. Hence, these are by

no means specially privileged children with unusually enriched backgrounds.

The fact that the children take comparatively few trials to reach criterion in both initial learning and transfer, is likely to be due to the extra care which E must take in running such young Ss. The procedure described above - in which E sits by the child and sets the situation as it were on each trial - is in a sense an ideal situation. It may well, in fact, be a procedure which would enhance learning for the older children of the first two experiments, in that it ensures that the child attends to the stimuli on each trial. In fact, even with the requirement that the child press the "correct" picture on each trial, not all children give their attention on all trials to the stimuli presented.

Experiment 4

Experiment 4 can only be considered as pilot work. Although a substantial number of children were run in this experiment - certain flaws in the execution of the experimental work make the results unacceptable in terms of reliability. Hence the details of the methodology employed will not be presented - but the general results which hold implications for the importance of the experimental problem, will be discussed.

Essentially kindergarten and fourth grade children were run in a size discrimination situation in a 2x2x2 design with the independent variables of age (kindergarten vs 4th grade), separation of the stimulus and response (0 separation vs 6" separation) and type of response (overt correction method vs non-correction method). In respect to the "type of response" variable, the overt correction method requires that following an error, S make a correction response. In the non-correction method, when S makes an error the trial is ended- he is not allowed to make a correction response.

The results in respect to the kindergarten children were fairly clear-suggesting that under separated conditions (stimulus and response 6" apart) the inclusion or absence of an overt correction response is not important. On the other hand under contiguous conditions (no separation between stimulus and response) the younger children learned more quickly with the overt correction method. Neither separation nor type of response appear, from this pilot study, to affect either speed of learning or errors to criterion amongst the fourth grade children.

The evidence of the kindergarten groups if the present results hold, suggest that the contradictory findings from a number of experiments in respect to the effect of correction vs non-correction method in young children's learning, may be attributable in part to the actual spatial arrangements of the experimental task.

The Relation of the Present Findings to the Classroom Situation and Some Comments.

One of the clear findings of the experiments described here- a finding which is supported by the results of a previous experiment by the present writer (Ginsberg, 1969) is that concept learning in young children is most efficient where the concept is introduced in the simplest context. In the experiment referred to above, where I was investigating the prepotency of number vs colour in the five-year old, I observed that Ss could not learn in 180 trials, run on 3 successive days, the concepts of equipollence and non-equipollence of sets where the objects in each of the pair of sets were different. However, when the pair of pictures presented on each trial were made up of circles only, most of the children learned the experimental concepts and all of the learners subsequently transferred with notable ease to the more difficult -different objects within a pair of pictures i.e. "unlike objects"- stimuli.

This finding, of the unequivocal superiority both of initial learning and subsequent transfer, of concepts learned under the simplest conditions has direct implications to the classroom situation where the teacher in the primary grades is, in particular, faced with the task of repeatedly introducing new concepts. Considering the first three experiments presented here, the most successful training situation was that in which the concept to be learned was the only one possible, given the stimuli presented - and along with this, there was little variation of irrelevant dimensions as possible. The different geometric arrangements of the objects in each picture presented, was a necessary variation- if the circles had been presented simply in a single line of circles, the child could have learned to respond to the length of the line rather than to the number of objects. However, it is possible that

variations in the spatial arrangement of the objects in a picture may prove a source of distraction either for the child who is developing very slowly, or for the under three-year-old. It may be that with the younger child- perhaps with the infant- I shall still find that the concept of "more than" may be acquired in the experimental situation, but that the stimuli must be even simpler than those described here. This is an experimental problem which remains to be investigated.

A very exciting finding of the present experiments - and one which again receives support from earlier experiments involving the learning of simple mathematical concepts (Ginsberg, 1969: Suppes & Ginsberg, 1962(a) and (b)), is that the young child can, quite easily, learn concepts which are traditionally assumed to be beyond his capacity. It seems, in fact, that the usual classroom situation cannot be considered to employ an optimal learning environment with respect to the actual capacities of the younger child. The area in which the child is, in his earlier years least adept is that of language, yet language is the medium through which attempts are made to teach him in the classroom- although there is little doubt that the same words do not necessarily convey the same meanings to each of a group of five year olds, for example.

On the other hand the child's capacity to learn through other than verbal means is very well established- the neonate can be classically conditioned, operant learning, shape and colour discrimination have all been established in the first year. Whether one prefers to call the process conditioning, S-R association, learning without awareness, learning through game-playing or, simply, learning, there is no doubt that the child can and does learn a multitude of responses and concepts at a very early age. It is precisely this kind of learning that the school situation neglects- and with children attending for formal education at increasingly earlier ages, it becomes additionally important that this excellent source of learning should be put to advantage.

Consider the experiments described here- the child, sometimes as young as 2 years and 10 months, is found to learn in short, ten-minute experimental sessions, which are in fact from his point of view, very attractive game-sessions, mathematical concepts which are usually considered appropriate at a very much older level. In fact there seems no reason from the present experimental results, to conclude that the simpler concepts involving numerosity are very different from, or more difficult than, such concepts as colour, form, etc. The difficulty which children have hitherto demonstrated in learning number concepts, may have simply been due to the fact that these concepts are difficult to explain verbally to the child.

I recognize, of course, that the highly effective experimental learning situations described here cannot be introduced casually into the classroom situation, and I do not suggest that teachers should attempt this kind of innovation. But the success of the methods used in the present experiments cannot be ignored. In fact, it is my intention in the coming year to explore the possibility (and effectiveness) of short periods of initial training in the Day Care Home, the Nursery School or in Kindergarten in learning situations roughly approximating those I have used in the present experiments. After which, I imagine, I shall have suggestions to present which will be highly pertinent to the classroom situation.

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